Living with *Linked Data*

Usage in a "live" production setting

About NXP Semiconductors

- Net Revenue: $4.82 billion (2013)
- Established: 2006 (former division of Philips)
- 55+ years of experience in semiconductors
- Headquarters: Eindhoven, The Netherlands
- Businesses
  - High Performance Mixed Signal: Automotive, Identification, Infrastructure & Industrial, Portable & Computing
  - Standard Products
- Customers & distribution partners
  - 10 largest OEM customers: Apple, Bosch, Continental, Delphi, Gemalto, Giesecke & Devrient, Huawei, Nokia, Siemens Network, Samsung and ZTE
  - 3 largest distribution partners: Arrow, Avnet and WPG

About Semaku

- Established: 2013
- Headquarters: Eindhoven, The Netherlands
- Consultancy services and software products
- Areas of expertise
  - Product Information Management
  - Linked Data
  - Content Strategy
- http://semaku.com
- info@semaku.com

Linked Data at NXP
So far, so good…

- Canonical data source for marketing master data
  - Provide the linking data
  - Unambiguous identifiers
- Using stored SPARQL SELECT queries to expose REST APIs
  - Results in tabular XML, JSON or CSV/TSV format
  - Easy to manage queries
  - Extremely quick to set up new APIs (15 – 30 mins)
- Able to answer previously unanswerable questions
- Minimal investment compared to traditional BW/BI projects

But we want more

- Faster, faster, more, more…
  - Daily RDF dumps not frequent enough
  - Do not contain all the data
- Phase out legacy systems
  - Reduce maintenance effort/costs
  - Manage data natively as RDF

Adding a new data source

PRODUCT LIFECYCLE MANAGEMENT

What is product lifecycle management

- “product lifecycle management (PLM) is the process of managing the entire lifecycle of a product … PLM integrates people, data, processes and business systems and provides a product information backbone for companies and their extended enterprise.” – Wikipedia
- Uses same basic EAV model that RDF is built upon
- Massively interlinked

Rationale

- PLM system is “closed”
  - No web services / API
  - Weekly reports with flattened data (CSV)
  - Changes sent as incremental messages over ESB (ASCII/CSV/XML)
- Need to migrate from a legacy ASCII message to new XML message
  - Flat message
  - Implicit links
- We need more data, but didn’t know exactly what
  - Wanted to be able to flexibly query the data leveraging the conceptual structure NOT the explicit structure in a particular serialization
- Point-to-point integration does not make sense
  - Specific mappings would have to be defined in the channel
  - Not robust and more effort to maintain

Why use Linked Data

- Consensus that a canonical model is a long term goal
- Challenge to define RDB and XML schema
  - Many classes
  - Reuse of properties across classes
  - Heterogeneous data
- Prototype with querying XML message using XSLT, XPath
  - Over 1 minute to build explicit tree structure from single ‘root’ item
  - A single message can contain over 1000 root items
  - Does not allow to traverse links in reverse direction
- Prototype with generating RDF (Turtle) and query with SPARQL
  - 200 ms to convert message AND run query (Jena in memory)
  - Using arbitrary length property paths

Modeling as RDF

- Bottom-up approach
- Model is already defined in source system
- Start with the instance data
- Data first, model later
  - RDF Schema is used to describe the data, not constrain
  - We didn’t even get round to making the RDF Schema yet!

Mapping to RDF (1)

- Map class and property names converted to CamelCase in URIs
- Follow convention that classes start with initial caps, properties lowercase

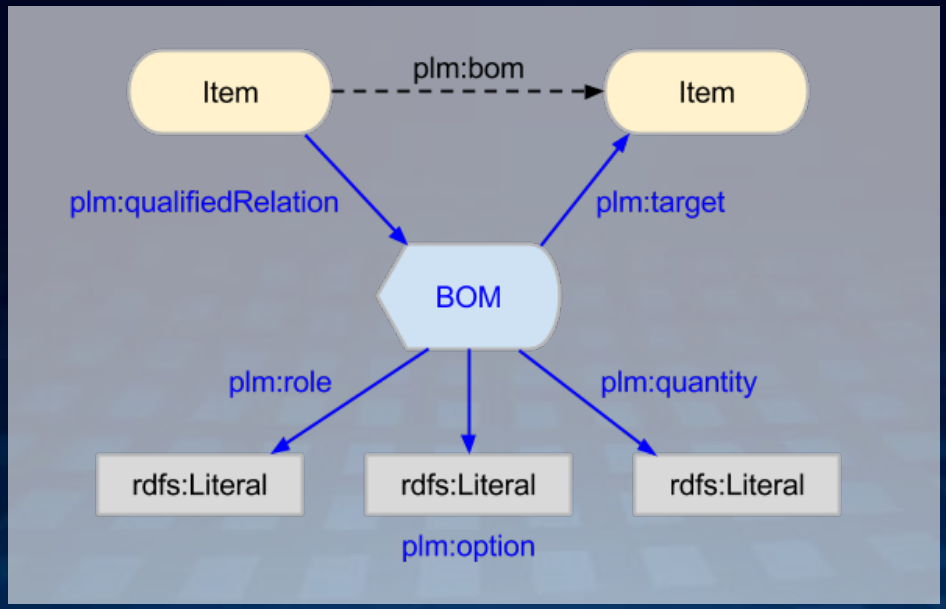
Name	Slug	CURIE
Sales Item	SalesItem	plm:SalesItem
CEPT	Cept	plm:Cept
Orderable Part Number	orderablePartNumber	plm:orderablePartNumber
Status	status	plm:status

- For instances we combine the class name and key id to build URI
  - `http://example.com/id/{class}/{id}`

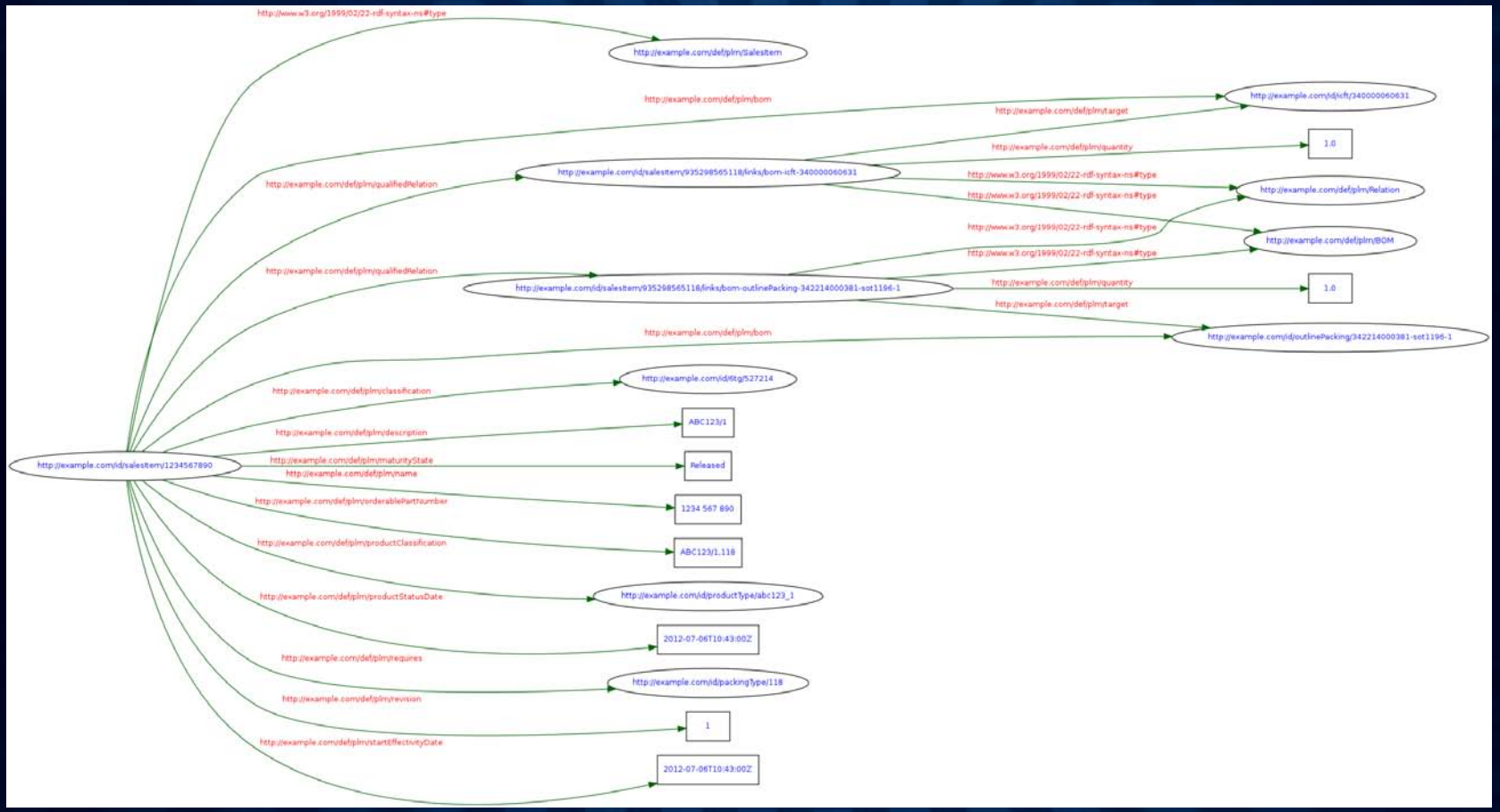
  Result
  - `http://example.com/id/salesItem/1234567890`
- Guarantees uniqueness

Mapping to RDF (2)

- Values do not have a datatype in the source XML
- By default map values to plain literals
- Specific match (regex) for timestamps and map to `xsd:dateTime`
- Could be extended in future
- Qualified links get reified



Example item description



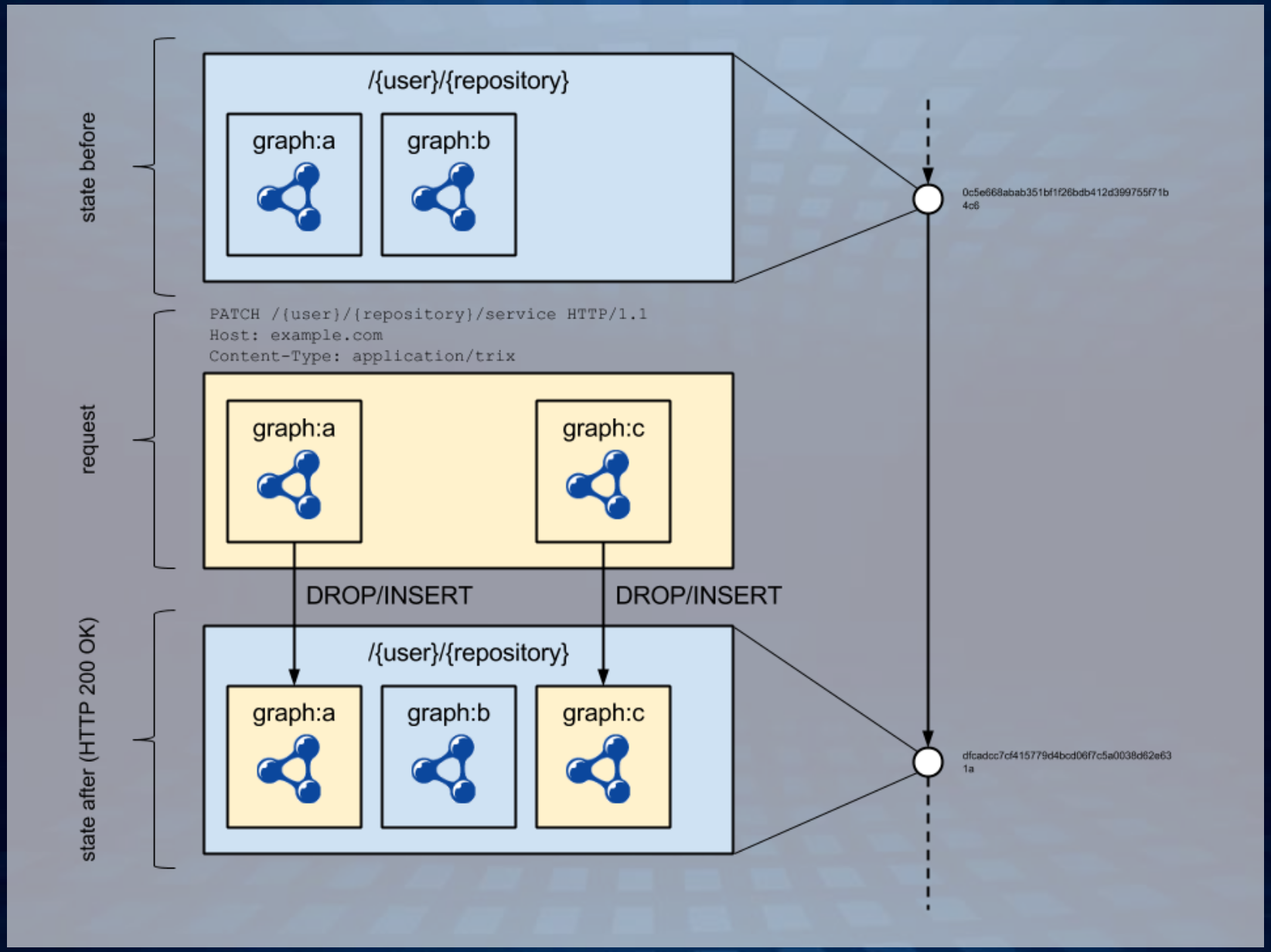
Visualization created with W3C RDF Validator (http://www.w3.org/RDF/Validator/)

Data management

- PLM system distributes Δ updates via XML messages over ESB
- A single message contains description of multiple items
- Messages can contain overlapping content
- Simplest approach is “Graph Per Resource” data management pattern
  - http://patterns.dataincubator.org/book/graph-per-resource.html
- Enables HTTP operations (GET, PUT) to manipulate individual resource descriptions

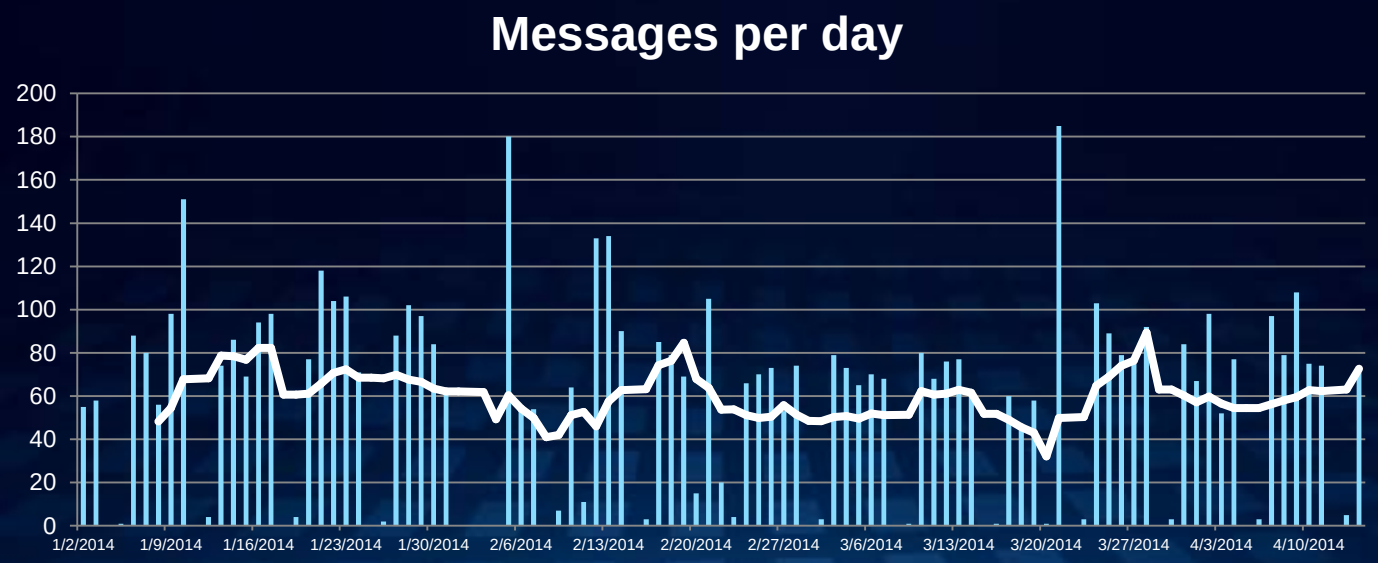
Apply changes to RDF graph store using Quads and HTTP PATCH

- We define `HTTP PATCH` using Quad data as equivalent to:
  - `DROP SILENT` operation on each named graph in payload, followed by
  - `INSERT DATA` operation on each named graph in payload
- Enables update of multiple resource descriptions (named graphs) in a single ACID transaction (i.e. HTTP request)
  - Same granularity as original message
  - No ambiguity about state of store, change is never partially applied
- Operation is carried out against the graph store service endpoint
  - Same endpoint as used with SPARQL 1.1 Graph Store HTTP Protocol
  - No `graph` or `default` parameter is passed with request
  - `Content-Type` header used to specify MIME type of the Quads format
    - `application/n-quads`
    - `application/trix`
    - `application/trig`
  - Quad data passed as message payload


state before
/{user}/{repository}
graph:a
graph:b
0c5e668abab351bf1f26bdb412d399755f71b4c8
request
PATCH /{user}/{repository}/service HTTP/1.1
Host: example.com
Content-Type: application/trix
graph:a
graph:c
DROP/INSERT
DROP/INSERT
state after (HTTP 200 OK)
/{user}/{repository}
graph:a
graph:b
graph:c
dfcadcc7cf415779d4bcd06f7c5a0038d62e631a

ETL pipeline

- PLM system distributes XML messages over ESB
- Generic XSLT transformation to TriX
- Load TriX to graph store using HTTP PATCH method
- Typically 3-4 seconds to transform and load a message



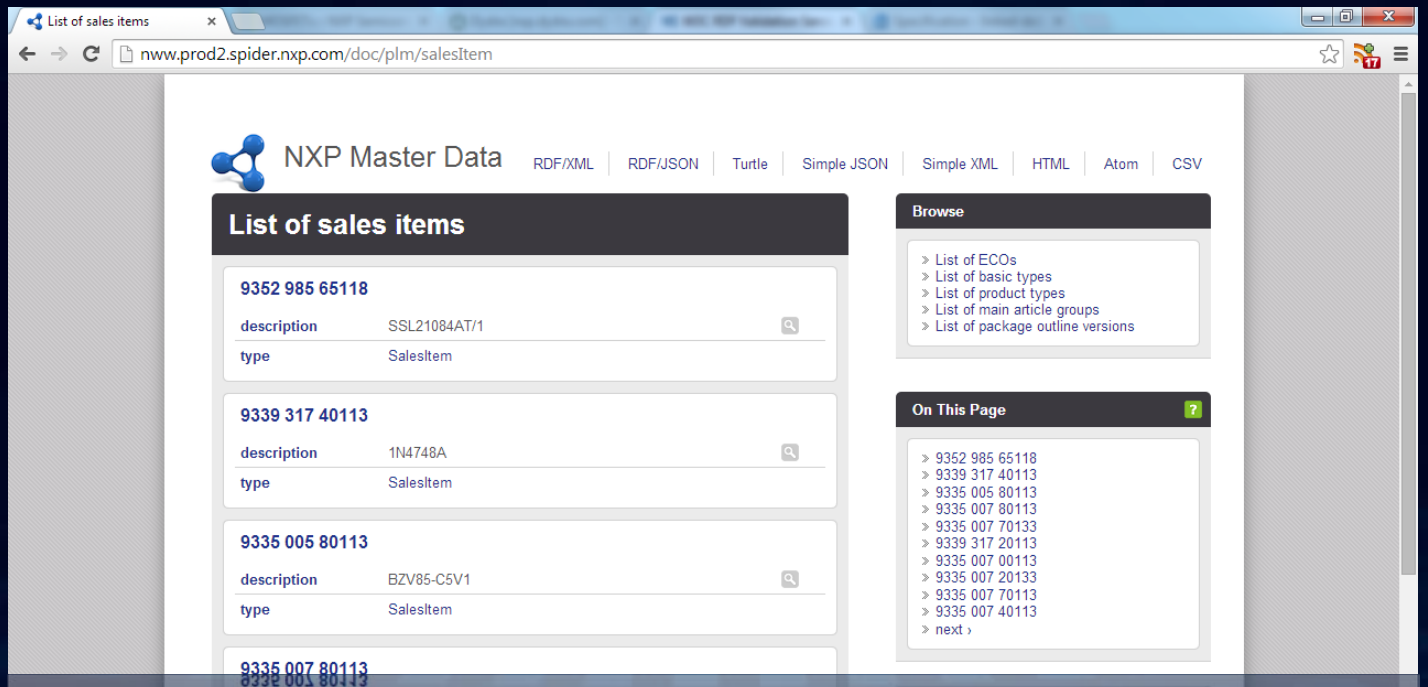
Facts and figures

- ~14M triples in dataset
- Describing ~0.5M items
- ~1.7M links between items

Per day	Typical	Max
Messages	60	185
Changed items	530	5,300
Sent items	14,000	77,000
Triples loaded	500,000	2,685,554

Publish as Linked Data

- Used Linked Data API to make data browseable as HTML
- Also provides simple API for XML, JSON and CSV



https://code.google.com/p/puelia-php/

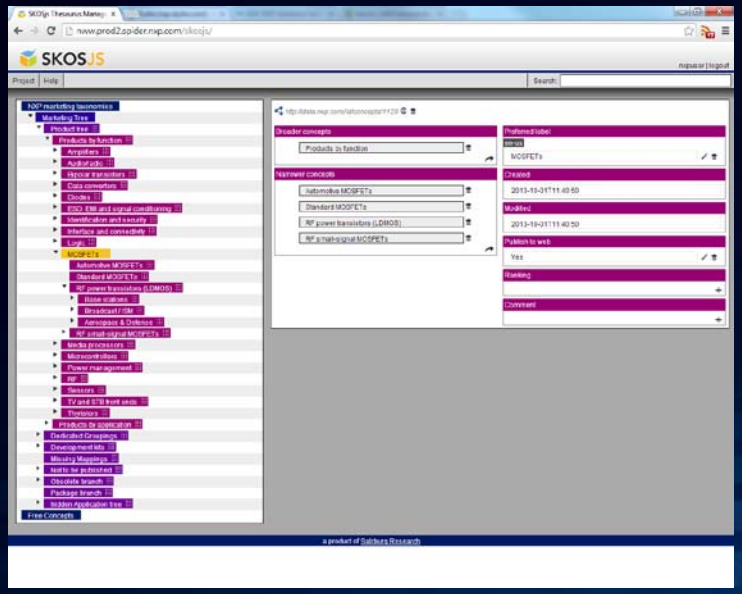
Souce: https://www.flickr.com/photos/mollystevens/3390423601 CC-BY-SA

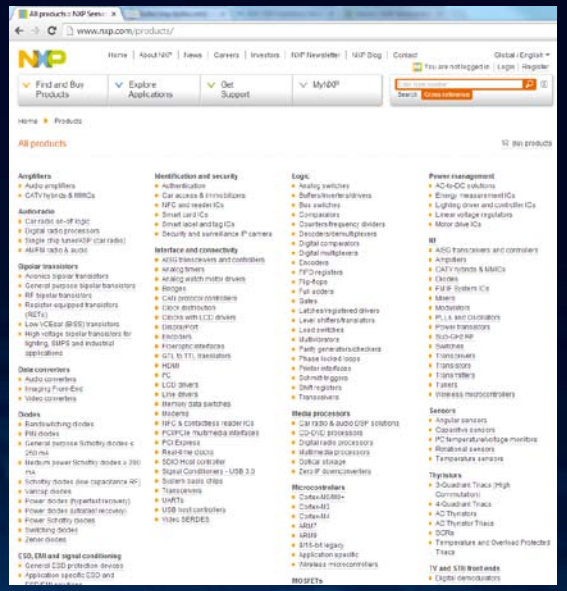
Building a Linked Data application

LINK MANAGEMENT

NXP Product Tree

- Part of main site navigation on NXP.com
  - “Marketing” view on NXP product catalog
- Not a strict tree structure
- Since October 2013 is managed as SKOS concept scheme using SKOSjs





https://github.com/tkurz/skosjs

Product placement

- Products need to be placed (linked) to product categories
- Products defined in PLM data set, categories in SKOSjs
- Different role and users to tree manager
- Decided to implement a simple application
- Use cases:
  - Find unassigned products
  - Search for products and categories
  - Add links
  - Remove links

Let's Play

- Decided to build application using Java version of Play Framework
- Approx 4-6 weeks to develop and test
- Application makes queries against graph store direct from client browser
  - Using SPARQL 1.1 Federated Query
  - Originally by populating pre-defined SPARQL templates and executing these against SPARQL endpoint
  - Now queries are stored in database and exposed as an API
    - Initial variable bindings can be passed as request parameters
- Results are in SPARQL Query Results JSON Format

SPARQL Query Results JSON Format

- Simple tabular results format for SELECT and ASK queries
- `Content-Type: application/sparql-results+json`
- Example response

```
{
    "head": {
        "vars": [ "btn", "desc", "csi", "psi", "status", "statusDate" ]
    },
    "results": {
        "bindings": [
            {
                "btn": { "type": "literal", "value": “BZL3615AHN" },
                "csi": { "type": "literal", "value": "No" },
                "psi": { "type": "literal", "value": "No" },
                "status": { "type": "literal", "value": "Development" },
                "statusDate": {
                    "type": "literal",
                    "value": "2014-02-03",
                    "datatype": "http://www.w3.org/2001/XMLSchema#date"
                }
            },
            ... more bindings ...
        ]
    }
}
```

Example 1: Get unassigned products

- SELECT query with no initial bindings

```
GET /nxp/marketing-tree/pp_get_unassigned_products.srj HTTP/1.1
```

btn	desc	csi	psi	status	statusDate
BTH3415TIO		No	No	Development	2014-02-03
BTM4500TIO		No	No	Development	2014-01-31
CHB3131		Yes	No	Development	2014-03-04
CHV7072		No	No	Development	2014-03-12
CHV7075		No	No	Development	2014-03-12
CHV8I1		No	No	Qualification	2014-01-23
CHV8M1		No	No	Qualification	2014-01-23
CHV8O1		No	No	Qualification	2014-01-23
CMD8H21MT-160B		No	No	Development	2014-04-07
CMG6H22MT-180Q		No	No	Production	2014-03-20

Example 2: Get products filtered

- SELECT query with a single binding for search string
- Initial bindings passed as parameter `$searchString`
- Literal values enclosed in quotes `"2n7002"`
- Parameter name and value URL encoded

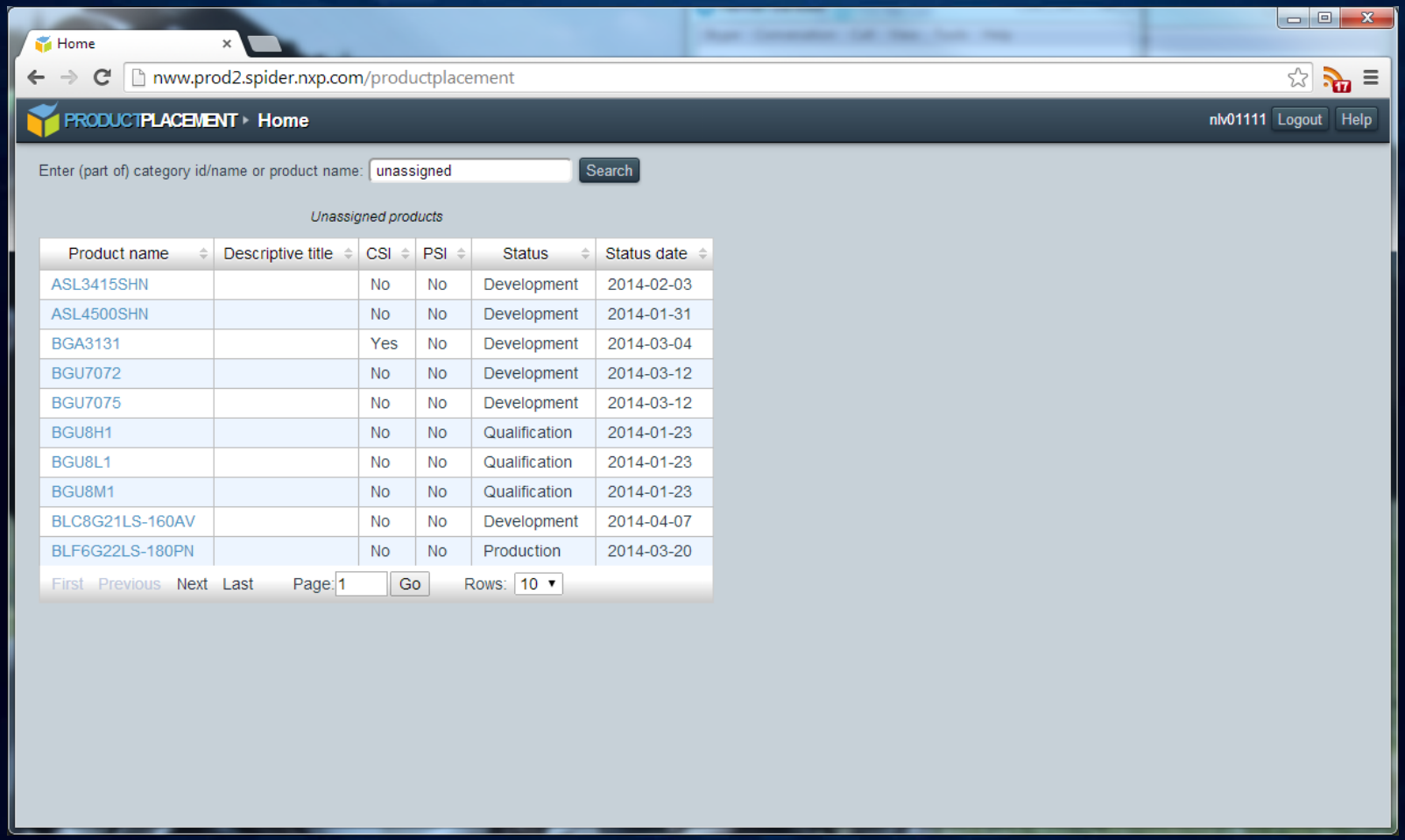
```
GET /nxp/marketing-
  tree/pp_get_products_filtered.srj?&%24searchString=%222n7002ck%22
  HTTP/1.1
```

btn	desc	csi	psi	status	statusDate
2N7002CK	60 V, 0.3 A N-channel Trench MOSFET	No	No	Production	2011-10-28

Example 3: Link product to category

- INSERT query with binding for product and category
- Initial bindings passed as parameters `$productId $categoryId`
- Literal values enclosed in quotes `"2n7002"`
- Parameter names and values URL encoded

```
GET /nxp/marketing-tree/pp_link_product_to_category.srj?
  %24productId=%22BFU915F%22&%24categoryId=%22208%22 HTTP/1.1
```


Home
nww.prod2.spider.nxp.com/productplacement
PRODUCTPLACEMENT ▸ Home
nlv01111 Logout Help
Enter (part of) category id/name or product name: unassigned Search
Unassigned products
Product name | Descriptive title | CSI | PSI | Status | Status date
ASL3415SHN | | No | No | Development | 2014-02-03
ASL4500SHN | | No | No | Development | 2014-01-31
BGA3131 | | Yes | No | Development | 2014-03-04
BGU7072 | | No | No | Development | 2014-03-12
BGU7075 | | No | No | Development | 2014-03-12
BGU8H1 | | No | No | Qualification | 2014-01-23
BGU8L1 | | No | No | Qualification | 2014-01-23
BGU8M1 | | No | No | Qualification | 2014-01-23
BLC8G21LS-160AV | | No | No | Development | 2014-04-07
BLF6G22LS-180PN | | No | No | Production | 2014-03-20
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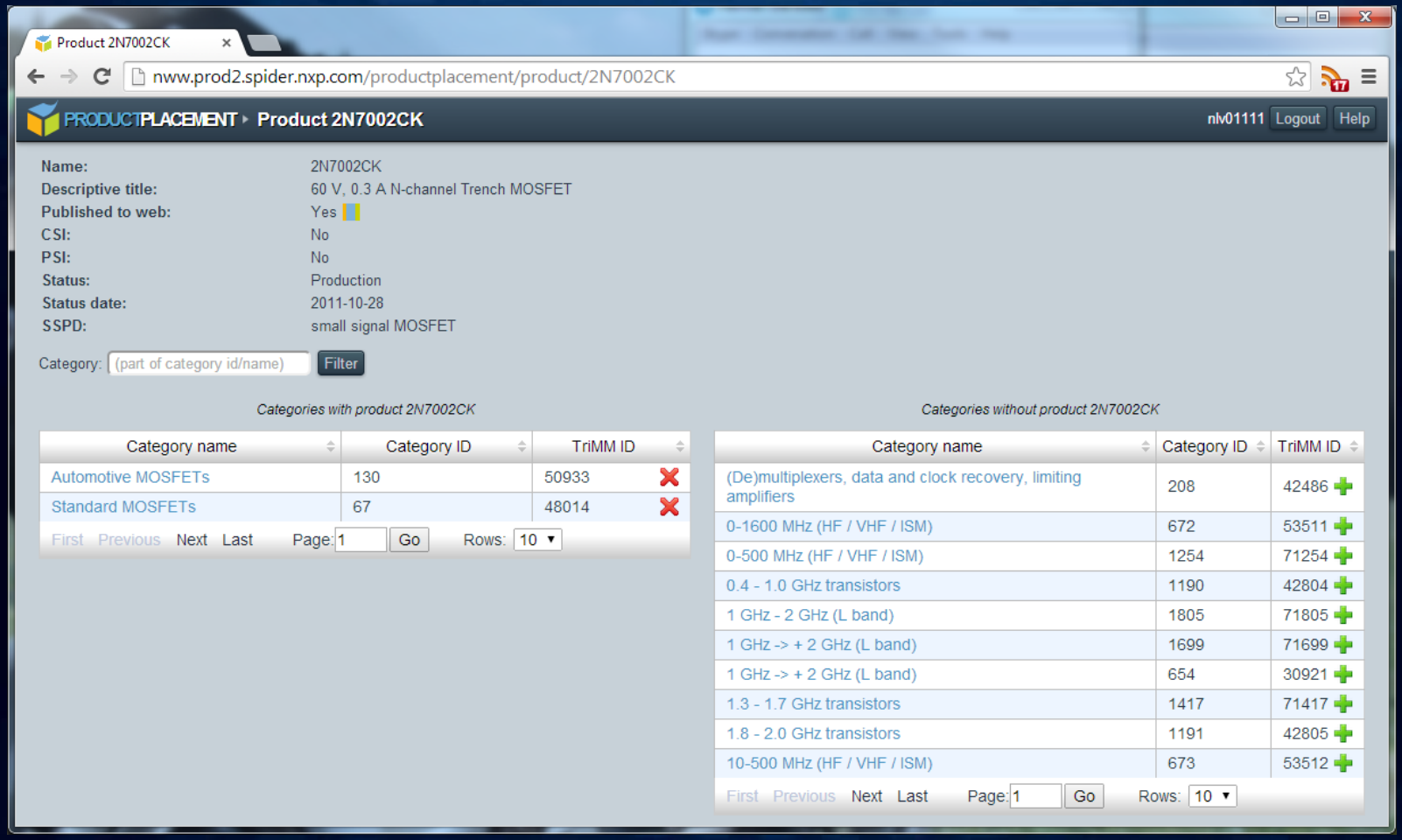
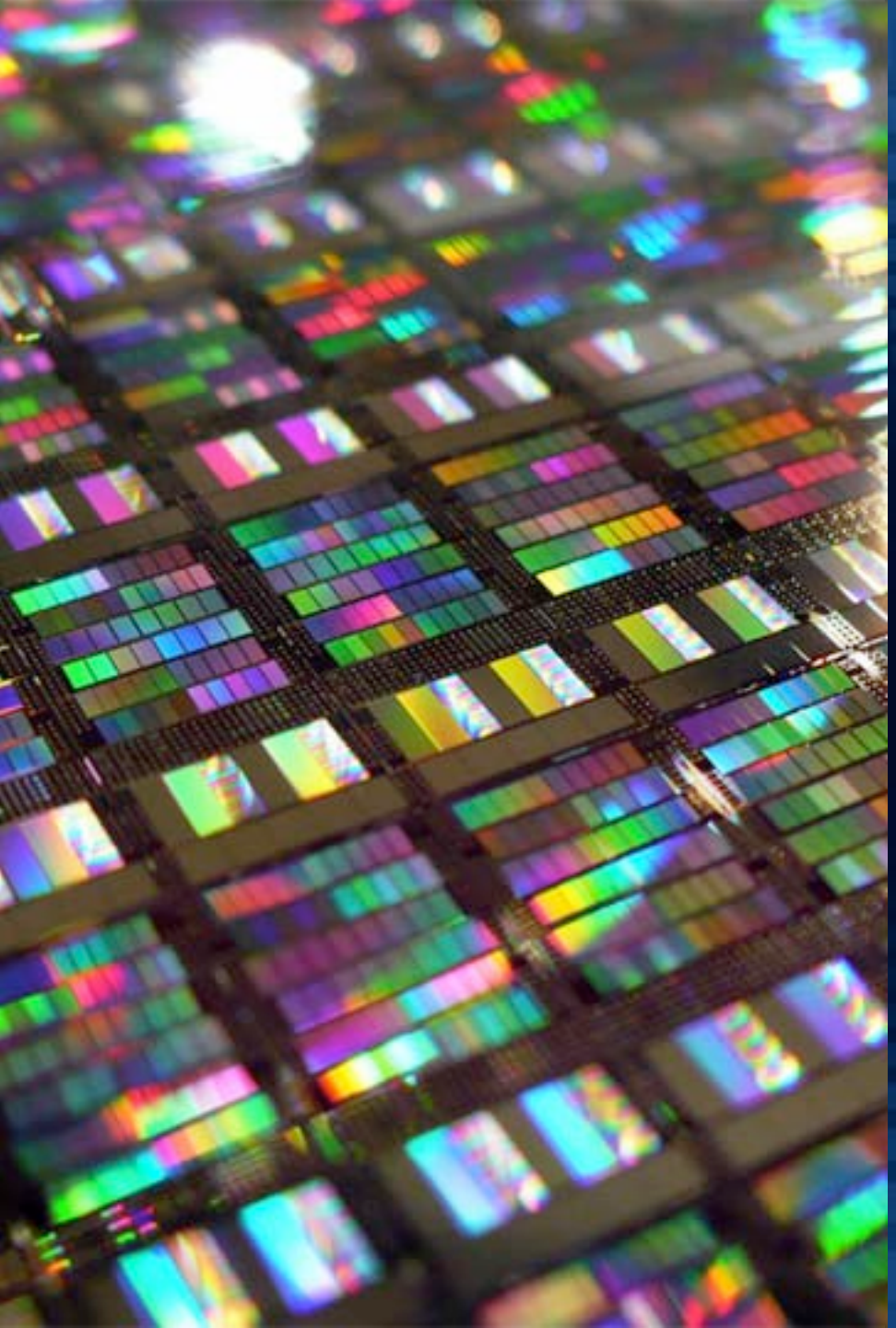

Product 2N7002CK
nww.prod2.spider.nxp.com/productplacement/product/2N7002CK
PRODUCTPLACEMENT ▸ Product 2N7002CK
nlv01111 Logout Help
Name: 2N7002CK
Descriptive title: 60 V, 0.3 A N-channel Trench MOSFET
Published to web: Yes
CSI: No
PSI: No
Status: Production
Status date: 2011-10-28
SSPD: small signal MOSFET
Category: (part of category id/name) Filter
Categories with product 2N7002CK
Category name | Category ID | TriMM ID
Automotive MOSFETs | 130 | 50933
Standard MOSFETs | 67 | 48014
First Previous Next Last Page: 1 Go Rows: 10
Categories without product 2N7002CK
Category name | Category ID | TriMM ID
(De)multiplexers, data and clock recovery, limiting amplifiers | 208 | 42486
0-1600 MHz (HF / VHF / ISM) | 672 | 53511
0-500 MHz (HF / VHF / ISM) | 1254 | 71254
0.4 - 1.0 GHz transistors | 1190 | 42804
1 GHz - 2 GHz (L band) | 1805 | 71805
1 GHz -> + 2 GHz (L band) | 1699 | 71699
1 GHz -> + 2 GHz (L band) | 654 | 30921
1.3 - 1.7 GHz transistors | 1417 | 71417
1.8 - 2.0 GHz transistors | 1191 | 42805
10-500 MHz (HF / VHF / ISM) | 673 | 53512
First Previous Next Last Page: 1 Go Rows: 10

Lessons learned

- Building a simple Linked Data application is easy
- SPARQL Federation is very useful
- Stored queries is a good approach to expose API
  - Front end developer doesn’t see SPARQL
  - Works for read and write



Publishing Linked Data

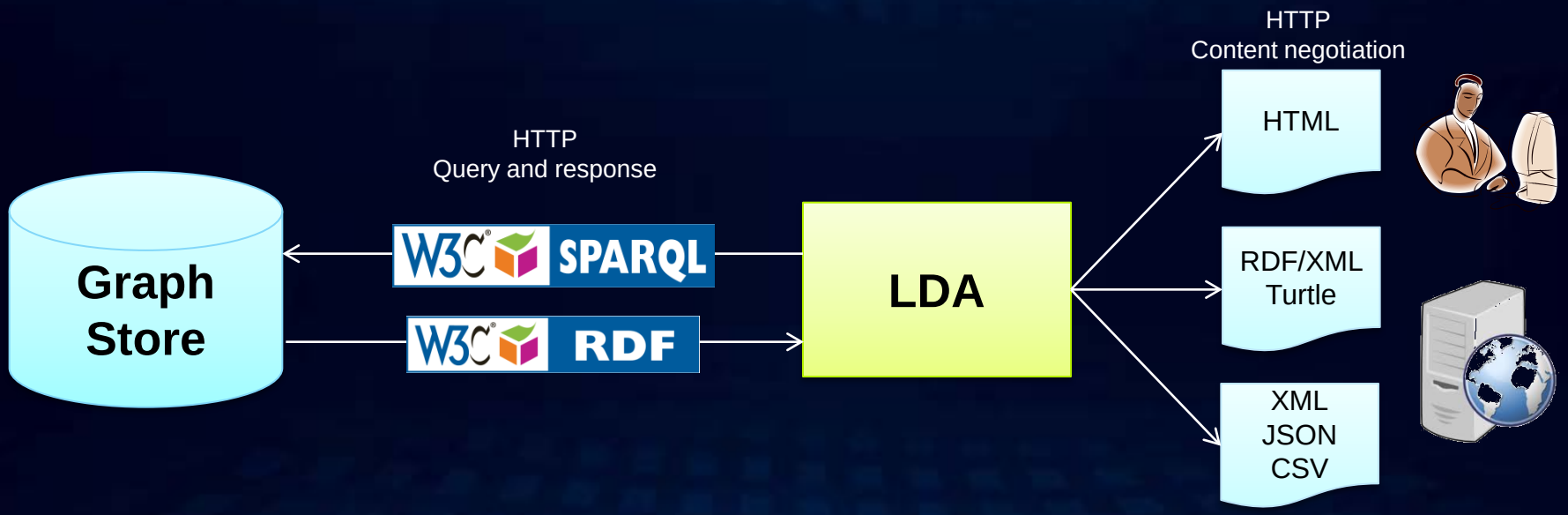
LINKED DATA API

Linked Data API (LDA)

- LDA defines a vocabulary and processing model for a configurable API layer intended to support the creation of simple RESTful APIs over RDF triple stores.
- The API layer is intended to be deployed as a proxy in front of a SPARQL endpoint to support:
  - Generation of documents (information resources) for the publishing of Linked Data
  - Provision of sophisticated querying and data extraction features, without the need for end-users to write SPARQL queries
  - Delivery of multiple output formats from these APIs, including a simple serialization of RDF in JSON syntax

LDA Architecture

- Use W3C web standards RDF, SPARQL for portable solution
- Work with any RDF graph store with only minor configuration



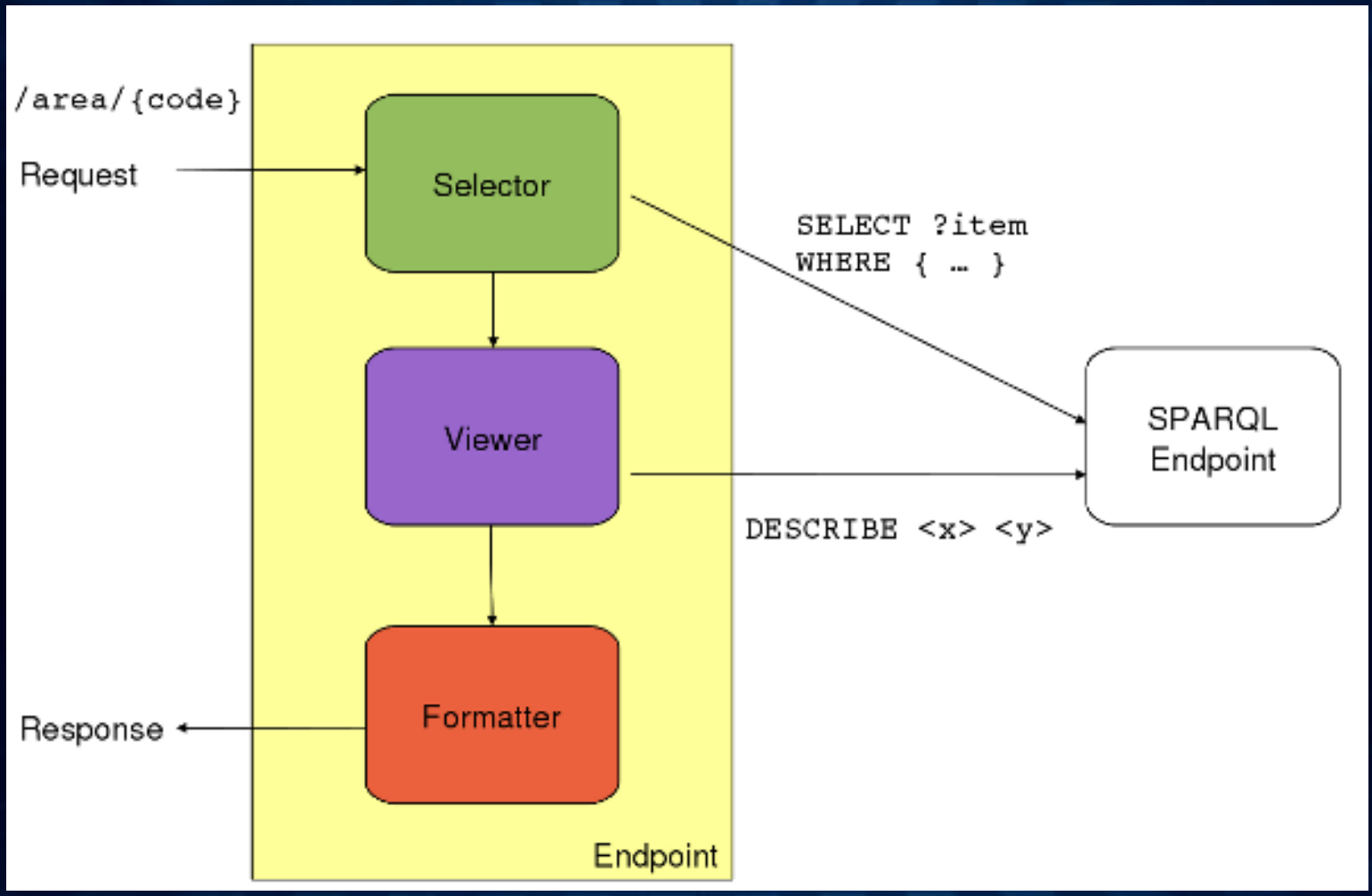
LDA is open source

- Open source specification: http://code.google.com/p/linked-data-api/
- Open source implementations:
  - Puelia (PHP): http://code.google.com/p/puelia-php/
  - Elda (Java): https://github.com/epimorphics/elda

LDA Processing Model

- **Identifying an Endpoint** -- GET request made to a particular URI is mapped to an **Endpoint** that describes further processing logic
- **Binding Variables** -- the API creates a number of variable bindings based on the structure and parameters of the incoming request, and the Endpoint configuration. These variables as well as the available API configuration and request metadata describe the **Context** for the execution
- **Selecting Resources** -- the API identifies a sequence of items who properties are to be returned. Usually this will be based on a **Selector** that describes how to identify a single item or an ordered list of resources, in concert with the available bindings
- **Viewing Resources** -- the API retrieves the desired properties of the identified resource, constructing an RDF graph of the results. This process is described by a **Viewer** that identifies the relevant properties of the resources
- **Formatting Graphs** -- the API identifies how to serialize the resulting RDF graph to the client. This process is defined by a **Formatter**

LDA Processing Model



LDA configuration

- LDA config files are declarative description of the API
- Describes
  - List and item endpoints
  - Selectors
  - Viewers
  - Formatters
- Written in Turtle
- Read by application at run time


Thank you